SEAFLOOR EARTHQUAKE MEASUREMENT SYSTEM
Quarterly Report

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                              Geo Systems Division 6256

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Project Description

The purpose of the SEMS project is to gather strong motion earthquake
data from offshore oil and gas leasing regions that are seismically
active. The principal areas of interest are offshore of southern
California, in the southern Bering Sea, and near the Aleutian Islands.
One SEMS unit was installed during 1985 in the Beta Field offshore of
Long Beach. Given that sufficient government and industry funding can be
obtained, the project will eventually emplace and monitor multiple SEMS
units in Alaskan waters where the greatest seismic hazards exist.

Progress

The Shell SEMS unit was interrogated on November 8, 1985. The unit is
functioning normally but only "noise" events were recorded this quarter.
The location of the SEMS unit is close (approximately 300 meters) to
Shell's Ellen and Elly platforms. Consequently, the absence of a
recorded earthquake event is conceivably attributable to excessively high
background noise caused by operations at the nearby offshore platforms.

In order to better understand the potential noise effect, earthquake data
from an earlier SEMS field exercise was re-examined. The SEMS
methodology used to detect and store events is central to understanding
the noise effect. SEMS uses high density magnetic bubble memory with a
finite storage capacity. A software algorithm controls the data
acquisition and storage functions to insure the most pertinent data are
stored. The algorithm first determines if an event of interest has
occurred and then determines whether or not to store the event in

magnetic bubble memory. Figure 1 shows a block diagram of the data acquisition system.
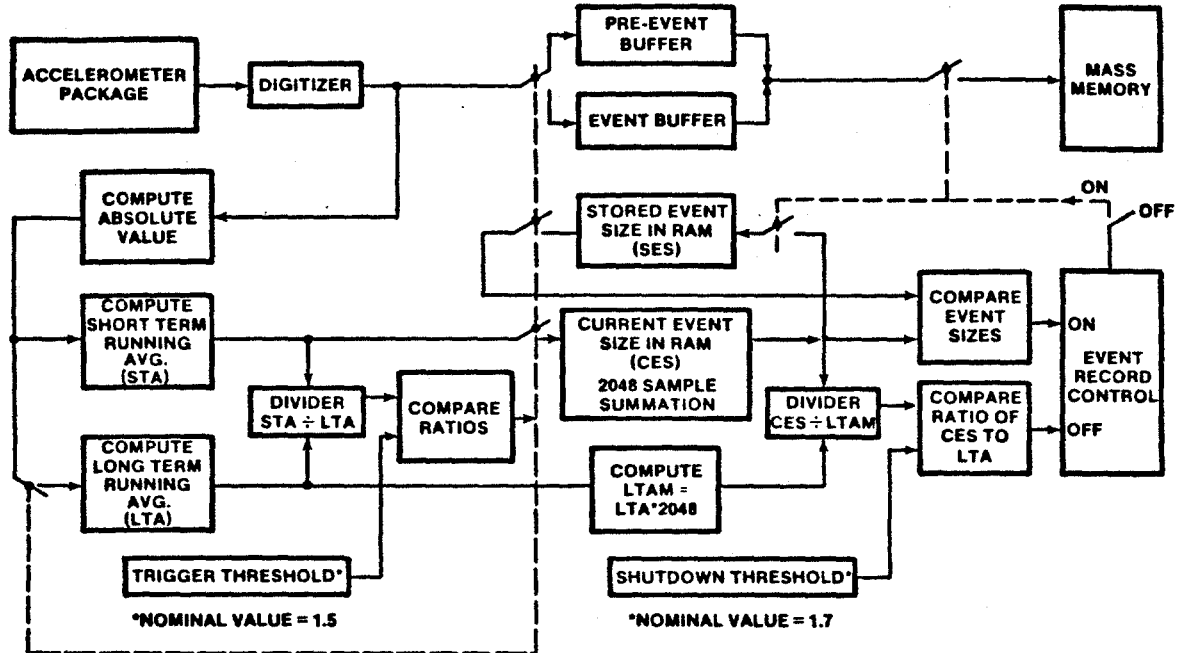

Figure 1. Data Collection Operational Sequence.

The criterion used to determine if the current level of seismicity is associated with a potential earthquake event is one used extensively by the USGS and other agencies. The method is based on continually computing a signal-to-noise ratio, with the assumption that the more recent data is the signature (signal) of a candidate event. The absolute value of the amplitude, A(t), of the output of the vertical accelerometer is used to compute a short-term average at time τ, STA(τ), and a long-term average at time τ, LTA(τ). More specifically,

$$STA(\tau) = \frac{1}{1.28} \int_{\tau-1.28}^{\tau} |A(t)| dt, \text{ and}$$

$$LTA(\tau) = \frac{1}{20.48} \int_{\tau-20.48}^{\tau} |A(t)| dt \quad .$$

The STA is the average of the last 1.28 seconds of data and is a measure of the current seismic activity (signal strength). In contrast, the LTA is the average of the last 20.48 seconds of data and is a measure of the background seismic (noise) level. If the signal-to-noise ratio (STA/LTA) exceeds a preset threshold value, nominally 1.5, the current data is treated as a candidate earthquake event.

The accelerometers are sampled 100 times per second and the data is placed in a 1.7-second pre-event buffer in RAM. If a data string is determined to be a candidate earthquake event by exceeding the signal-to-noise threshold value, the LTA computation is halted as is the data transfer to the 1.7-second pre-event buffer. Incoming data from the accelerometers are then recorded in an event buffer section of RAM and a 20.48 block event size (BES) is computed. Specifically,

$$BES = \int_{\tau}^{\tau+20.48} |A(t)| dt \quad .$$

At the end of the 20.48 seconds, the BES is used to determine whether or not to store the data currently stored in the RAM event buffer into the magnetic bubble memory.

The bubble memory is divided into fifty-six 22.18-second blocks. The microcomputer has a section in RAM called the block information section which contains the status of each block (i.e., whether a block has event data or is vacant). If a block contains event data, the size of the block is also recorded. Since an earthquake event can be longer than 20.48 seconds, an event can have multiple blocks of data in the bubble memory. When comparing block event sizes, a check is first made to determine if any vacant blocks exist. If a vacant block is found, the present event and the pertinent information about the event, such as the time and date of the event, are stored in the bubble memory and the block information in RAM is updated. If no blocks are vacant, a comparison of event sizes is made to determine if the present event is larger than the smallest event size in the bubble memory. If a smaller event is found in the bubble memory, all of the blocks for that event are declared vacant and the present event is stored in one of the vacant blocks. If the present event is smaller than the minimum previously stored, the event is declared over, the event is not stored in the bubble memory, and the system starts looking for another event.

Once the first block of data of an event has been stored in the bubble memory, a new block of data is acquired. At the end of this subsequent block, a block size is calculated as previously described. For blocks of an event other than the first, a shutdown ratio is computed based on the

an event other than the first, a shutdown ratio is computed based on the ratio of the block size to the LTA. If the ratio is less than a preset level, nominally 1.7, the event is declared over and the system begins looking for another event. Otherwise, the event is considered still in progress and the procedure for determining whether or not to store the present event data in the bubble memory continues as described above. This procedure continues until the new event is declared over or until all 56 blocks are filled by one event (an unlikely outcome). When an event is declared over, the LTA calculation is restarted and the new data is input to the pre-event buffer as before. The system will not declare an event until the 1.7 second pre-event buffer is filled with new data.

Data from the earlier SEMS unit, in particular the BES, were compared to that recorded by the present unit. More specifically, a comparison was made between the BES for the largest noise event recorded by the Shell SEMS unit and the BES of the most significant earthquake event recorded by the earlier SEMS unit. This earlier event was the Santa Barbara Island Earthquake which took place on September 4, 1981. The BES for the earthquake was 2.60 gravity units and that of the largest noise event was 0.72 gravity units. Clearly, the earthquake would have been recorded even in the present "noisy" environments.